The Autism Social Anhedonia Scale: A social reward processing scale for ASD

Sean McWeeny

The University of North Carolina at Chapel Hill

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Committee Chair_____
Dr. Gabriel Dichter

Committee Member_____
Dr. Patrick Curran

Committee Member _____
Maya Mosner

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Abstract

Traditionally, autism spectrum disorders (ASD) have been examined through behavioral manifestations of core social cognitive deficits, such as theory of mind. The Social Responsiveness Scale (SRS), which is the standard scale for measuring ASD symptomatology, is rooted in literature based on these cognitive deficits. Studies have come to suggest that social motivational issues maybe be underlying these deficits rather than purely cognitive systems. The goal of the present study is to develop a novel scale to assess ASD symptomatology from a social reward processing perspective using modern factor analytic techniques. There is currently no scale to assess social reward processing in ASD, and the goal of the ASAS is to create a useful tool for clinicians in assessing social reward processing difficulties. Based in neurobiological research on the reward processing system, the Autism Social Anhedonia Scale (ASAS) was designed with three factors: social liking, social wanting, and social learning. We generated our own items and received feedback from experts in ASD research and refined those items. The majority of participants' responses were collected via an online survey without a clinical visit. Participants completed the ASAS, the Autism Quotient (AQ), and SRS. By systematically trimming down items using confirmatory factor analysis (CFA) and exploratory factor analysis (EFA), we reached a final model that can be used as a stepping-stone toward future development of this measure. We then related this measure to the SRS, finding a moderate relationship between the ASAS and SRS, which demonstrated that while they are related, the ASAS is divergent from the SRS.

The Autism Social Anhedonia Scale: A social reward processing scale for ASD

Autism spectrum disorder (ASD) is a lifelong neurodevelopmental disorder that affects an individual's social functioning. The Diagnostic and Statistical Manual (DSM-5) categorizes ASD as an Axis II disorder with two primary domains: repetitive and restricted patterns of behavior and pervasive social communication deficits (American Psychiatric Association, 2013). Symptoms from both domains must be present to diagnose ASD. Prevalence estimates of ASD have risen rapidly in recent years, from approximately 30 in 10,000 to 60 in 10,000 a decade ago (Fombonne, 2003). The most current Center for Disease Control estimates that 147 in 10,000 (one in 68) children in the United States have ASD (Baio, 2012). ASD disproportionately affects males, who make up 82% of cases. Although ASD is a disorder independent of intellectual disability (ID; IQ<70), 31% of individuals with ASD are affected by ID, with another 23% in the borderline range (IQ=71-85).

History

Dr. Leo Kanner was the first person to describe autism in depth in 1943, when he detailed cases of children who struggled with social interaction but had remarkably high intellect (Kanner, 1943). Since this seminal paper, autism has had a contentious history in terms of its definition and causes. In the 1960s, due to the often socially cold nature of autistic children, the popular theory was that autism was caused by mothers who were not loving toward their child, who were deemed "refrigerator mothers" (Baker, 2013). Additionally, from its initial description and until 1980, autism was still considered by the DSM to be a type of childhood schizophrenia (American Psychiatric Association, 1968).

Social Cognition Theories of Autism

In the 1980s, new studies on social cognition and theory of mind (ToM) were launched, resulting in novel autism research that differentiated it from schizophrenia. ToM is the concept that an individual is able to understand him or herself as a separate entity from other people. ToM helps children to understand others' perspectives, affective states, and desires. Baron-Cohen and his team of researchers (1985) used a puppet play paradigm, the Sally-Ann task, to demonstrate that children with autism have deficits in ToM. Typically, children develop ToM by age 5, but individuals with ASD fail to develop ToM well beyond this age (Baron-Cohen, Leslie, & Frith, 1985). When tested with the 'reading-the-mind-in-the-eyes' task (a ToM take that asks participants to interpret the mental state on another person based only on seeing their eyes), individuals with ASD performed significantly worse than individuals without ASD, with differential activation in the amygdala (Baron-Cohen et al., 1999). These findings suggest that individuals with ASD cannot infer others' perspectives and affects as well as their typically developing peers, and that there are biological differences underlying these behaviors. ToM deficits from Sally-Ann task as well as from the 'reading-the-mind-in-the-eyes' task established social perception and social cognition as targets of autism research.

Following this theory, many researchers have examined the effects of the neuropeptide oxytocin (OXT) on social perception in ASD, which is implicated in trust (Hollander et al., 2007; Bethlehem, Baron-Cohen, van Honk, Auyeung, & Bos, 2014; Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005). OXT is a hormone that is thought to affect social orienting and social reward through the dopamine pathway (Bartz, Zaki, Bolger, & Ochsner, 2011). Preliminary evidence from these studies suggests that intranasal OXT administration may bolster social cognition and social perception in individuals with ASD (Hollander et al., 2007). Although

there is no consensus on whether oxytocin will have therapeutic effects (Bethlehem, Baron-Cohen, van Honk, Auyeung, & Bos, 2014), it is clear that increased social cognition is at the forefront of this hormone treatment.

The Social Responsiveness Scale

To reflect the social communication deficits in ASD, Constantino and his team of researchers developed and validated the Social Responsiveness Scale (SRS) (Constantino et al., 2003). The SRS has since become one of the most commonly used indices of ASD symptom severity. The SRS consists of 65 items with five subscales: social awareness, social cognition, social communication, social motivation, and characteristic autistic mannerisms. These 5 subscales clearly reflect the social cognitive deficits seen in a multitude of laboratory tasks. While there is a subscale for social motivation, its assessment is based on items such as "seems more self-confident when interacting with others," "separates easily from caregivers," and "has good confidence," which seem definitively different than social motivation as we currently understand it. The SRS is an extremely useful tool in assessing ASD symptoms, and the purpose of the present study is not to replace it.

The Social Motivation Theory of Autism

Recent research has focused on a potential social motivation theory (SMT) of ASD that complements social cognition theories (Chevalier, Kohls, Troiani, Brodkin, & Schultz, 2012). This theory operates under the assumption that social cognition deficits observed in ASD are a direct result of dysregulated social motivational processes. If a child is unmotivated to engage in social behavior and does not experience typical reward, then he/she will not engage in social behaviors. The SMT, like the social cognition theories, is neurobiologically driven, with research implicating the ascending mesolimbic dopamine (DA) system's role in response to rewarding

stimuli (Boltz, Zaki, Bolger, & Ochsner, 2011). The SMT and social cognitive theories are in opposition regarding their proposed underlying deficits in ASD. However, the behavioral deficits seen as the child develops are most likely a combination of initial deficits in both social motivation and social cognition that have a cascading effect, causing persistent communication deficits.

Reward Processing

In order to understand or advance the SMT, it is important to understand the underlying mechanisms in reward processing as a system. Reward processing is mediated by the mesolimbic DA system and has four primary domains: reward motivation (anticipation or wanting), reward outcome (liking), reward learning, and persistent habitual behaviors (Dichter, Damiano, & Allen, 2012). Many neurodevelopmental and psychiatric disorders and genetic syndromes such as addiction, depression, schizophrenia, and ASD have dysregulated reward processing systems. Although these four systems are all part of the greater reward processing system, they are theoretically and neurobiologically independent. Parsing these separate systems is key to understanding the development of dysregulated reward processing (Berridge & Robinson, 2003). Previous research has validated scales for restricted interests and repetitive behaviors, but no scale to date has assessed social reward processing (Aman, Singh, Stewart, & Field, 1985). Thus, for the purpose of this research, we will focus on measuring reward wanting, reward liking, and reward learning.

Social Motivational Additions and Challenges to Social Cognition Theories

Traditional interventions for individuals with autism have focused on eliminating specific behaviors and reinforcing desired outcomes through the use of rewards (Virues-Ortega, 2010). They have generally been cognitively and socially effective for many individuals with ASD,

except for those whose reward processing system is most impaired (Kohls, Chevallier, Troiani, & Schultz, 2012). Impairment seems to be greatest in the reward wanting domain, while reward liking appears to be intact (Kohls, Chevallier, Troiani, & Schultz, 2012).

Although social cognition theories remain at the forefront of research, recent contrasting evidence has challenged the foundations of this theory. Baron-Cohen's ToM research has been challenged most recently by Peterson et al. (2013). In this study, the researchers employed a Dot-Midge task, a similar paradigm to the Sally-Ann task examining ToM, with two additional features. In this task, researchers incorporated reward (a desired prize) to try to motivate participants to answer the question correctly. The task also includes competition such that two people are competing for the prize along with the child. Using competition and reward, the participants with ASD demonstrated intact ToM in the presence of external motivation. More specifically, children with ASD performed extremely well on this task in comparison to their performance on the original Sally-Ann task. Similarly, children with ASD performed better on a ToM task relative to controls when an experimenter was not present for the administration of the task (Chevallier et al., 2014). These studies suggest that deficits in ToM are not based solely in the lack of social cognitive skills, but rather that there is a social motivational dimension underlying the social cognitive deficits.

The Autism Social Anhedonia Scale

There is currently no measure that directly assesses social reward processing in ASD. In response to the recent theoretical advances in the social motivational aspects of ASD, we developed a measure to match current research. The current measure, the Autism Social Anhedonia Scale (ASAS), has been carefully designed for caregivers of children and adolescents with ASD from 8-17 years old. We expect to confirm three distinct factors from our scale items:

social wanting, social liking, and social learning. We will use a continuous scale slider to support a nuanced, spectral approach to ASD symptom measurement. Discrete anchors are avoided because individuals with ASD often have extreme attention to detail and rigidity. The ASAS is not designed to replace the SRS, but we believe that this scale will be a useful addition to the ASD research community.

Method

Participants

Caregivers of children with ASD were recruited through the Autism Society of North Carolina (ASNC) listserv and the Carolina Institute for Developmental Disabilities (CIDD) Subject Registry. The majority of our sample came from an online source (n=107) while a small number (n=7) received our measures as part of an ongoing study examining developmental aspects of reward processing. These seven participants had their ASD diagnosis confirmed using the Autism Diagnostic Observation Schedule (ADOS-2). Caregivers could and did select multiple options for diagnosis; as a result, these diagnoses were often not independent, particularly case of Asperger's and ASD (n=9) or ASD and HFA (n=12). Every participant reported having at least one diagnosis that would now fall under the DSM-5 criteria of ASD, even though they may have received a different diagnosis under DSM-IV. The participants were aged 8-17 (M=10.96, SD=2.21). Full descriptive statistics can be found in Table 1, Appendix A.

Measures

The Autism Social Anhedonia Scale (ASAS) is a novel measure with 45 items and three subscales: 15 items assess social wanting (e.g. did your child miss friends or extended family between visits), 14 assess social liking (e.g. did your child enjoy receiving holiday or birthday cards), and 16 assess social learning (e.g. did your child try to change inappropriate behavior

based on peer feedback). For the purpose of this study, we used only the informant report version. Each item is scored on a 100-point scale based on a continuous scale slider.

The Social Responsiveness Scale (SRS) (Constantino & Gruber, 2002) is a 65-item measure with five subscales assessing social awareness, social cognition, social communication, social motivation, and characteristic autistic mannerisms. The SRS is a 4-point Likert-type scale with informant and self-report versions. We only used in informant report version of the SRS. The whole scale score is designed to represent an index of ASD symptom severity after a t-score conversion.

The Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) was developed as a screening measure for individuals who self-reported as having an ASD diagnosis. There are 3 versions (Adults >16, Adolescents 12-15, and Children 4-12) of the AQ, and only the adolescent and child versions of the scale were administered through Qualtrics given the age range recruited online (ages 8-15). The AQ-Adolescent is scored from 0-50, with 80% to 90% of individuals with ASD scoring above a critical score of 30 (Baron-Cohen, Hoekstra, Knickmeyer, & Wheelwright, 2006). The AQ-Child version is scored from 0 to 150 with a critical cutoff score of 76 being highly sensitive and specific (95%) (Auyeung, Baron-Cohen, Wheelwright, & Allison, 2008).

Procedure

Items for the ASAS were written and piloted on a six-point Likert-type scale. These items were sent to ASD experts who gave valuable feedback in refining the items and the scale as a whole. Once we refined the list to 45 items, and piloted the items, we decided to change to a slider scale to support a spectral approach to social reward processing difficulties in ASD.

All questionnaires were administered via Qualtrics®, an online survey administration site. An example of the Qualtrics interface with the ASAS can be found in Appendix A, Figure 2. Participants recruited online filled out a waiver of consent through Qualtrics, and participants recruited through the ongoing developmental study signed a consent form in person. The demographics were always collected first, and for the majority of participants, the ASAS, AQ, and SRS followed in that order. For the participants who did not receive the AQ, the SRS was administered prior to the ASAS, among a battery of other questionnaires.

The online participants received the Autism Quotient (AQ-Child or AQ-Adolescent) as a confirmation of diagnosis, and the recruitment information was sent specifically to parents of children with developmental disabilities. We did not exclude any cases based on the AQ as only 12.5% of AQ-Child and 17.1% of scores on the AQ-Adolescent did not meet the critical score to meet for ASD (AQ-Child M=94.2, SD=16.8; AQ-Adolescent M=33.6, SD=5.7).

Data Analysis

The primary methods used for evaluating the Autism Social Anhedonia Scale were confirmatory factor analysis (CFA) and exploratory factor analyses (EFA) if model fit is poor. Model fit was tested using the root-mean square error of approximation (RMSEA), Tucker-Lewis Index (TLI) (Tucker & Lewis, 1973), comparative fit index (CFI) (Bentler, 1990), and a chi-square test. All of the factor analyses were run using MPlus (Muthén & Muthén, 1998-2015). Modifications suggested in MPlus will be made only if the suggested modification is justified by theory. We also plan to look at the distributions of the individual items, and distributions of sum scores, and inter-item correlations to determine whether individual items or subscales have enough variability and association to be included in the factor analysis models.

The Biolmedical Institutional Review Board (IRB) has reviewed and approved this study as part of a larger study examining developmental aspects of reward processing in individuals with and without ASD.

Results

Reliability and Inter-Item Correlations

The inter-item correlation matrices were calculated for each of the three subscales for the ASAS. In summary, Cronbach's alpha was high (α=.892) for social wanting (ASAS_1-ASAS_15), high (α=.855) for social liking (ASAS_16-ASAS_30), and high (α=.875) for social learning (ASAS_30-ASAS_45). Subscale inter-item correlation matrices can be found in Tables 2-4 in Appendix A.

During this phase of analysis, we discovered that all three reverse-scored items were the least correlated with the rest of their respective subscales and were a decrement to Cronbach's alpha when included. These findings, along with previous research on scale development (Woods, 2006), led us to exclude these items from later factor-analytic models, reducing the number of items to 42.

Distribution of Item Responses and of Sum Scores

We believe social wanting, social liking, and social learning to be normally distributed throughout the population. However, as we know, these reward systems are atypical in individuals with ASD. We would therefore expect our item responses to trend toward the extremes. The distribution of nearly every item was highly skewed and kurtotic due to the number of extreme responses, with many items bi-modally distributed at the extremes, or with severe positive skew.

Regression Analyses

We calculated sum scores for each subscale (i.e. social wanting, social liking, and social learning) to see if any of the demographic factors (i.e. race/ethnicity, socioeconomic status, diagnostic category, intellectual disability, age) were significant predictors of variance in the subscale sum scores. The hierarchical regression analysis for social wanting showed that diagnoses of ASD and Pervasive Developmental Disorder (PDD-NOS) explain a significant portion of the variance in social wanting sum scores above and beyond other demographic factors listed (F change = 5.504, $p<.01$). All of the factors explained 16.6% of the variance, but after adjusting for multiple predictors, the adjusted R^2 is .065.

For social learning, the hierarchical regression analysis identified intellectual disability (ID) as a significant predictor of social learning sum scores over and above the other factors included in model (F change = 6.253, $p<.05$). All of the factors explained 15.5% of the variance, but after adjusting for multiple predictors, the adjusted R^2 is .051. None of the demographic factors explained a significant portion of variance for social liking ($R^2=.068$, $p>.05$). Based on these analyses, we ran a conditional CFA using ID as a predictor but these results did not change model fit and a significant path from ID to the latent variables was not identified, so this model is not presented here.

Factor Analysis and Item Reduction

We conducted an unconditional CFA with 42 items on their original factors (excluding the reverse-worded items). We used a robust maximum likelihood estimator (MLR) instead of a maximum likelihood estimator (ML) because of the skew and kurtosis of the item distributions. The model fit was extremely poor ($\chi^2(816)=1718.652$ $p=.000$, CFI=.633, TLI=.613, RMSEA 90% CI =.092-.105) due to the large number of estimated parameters and low number of research participants. R^2 values from this CFA can be found in Table 6, Appendix A. We didn't

use any of the modification indices because the model fit was poor and we were estimating more parameters than we had items. It was clear that we needed to reduce this scale's size in order to create a fitting model, given the relatively small number of participants in our sample. Based on the poor fit of this model, we moved to an exploratory factor analysis (EFA) with the intention of further reducing items or potentially changing our factor structure. We used an oblique geomin rotation, as our factors were highly correlated in the first CFA as expected.

The EFA showed that a four-factor solution created a significant improvement in model fit over a three-factor model (3F: $\chi^2(738)=1497.537$ p=.000, CFI=.691, TLI=.640, RMSEA 90% CI =.088-.101 ; 4F $\chi^2(699)=1361.398$, p=.000, CFI=.731, TLI=.668, RMSEA 90% CI =.084-.098, $\Delta\chi^2$ (39)=118.001, p<.001). The geomin rotated factor loadings (Table 7, Appendix A) showed that items that loaded on this fourth factor were social/electronic media related (e.g. checks texts or email for messages from friends). In light of these findings, we conducted a CFA with 4 factors.

Despite the poor fit of the four-factor model ($\chi^2(813)=1606.287$ p=.000, CFI=.678, TLI=.659, RMSEA 90% CI =.085-.099), and potential of a Heywood case, we felt that there were important indices to be gathered from the output, only if there was strong theoretical evidence to support making the suggested changes. The MPlus modifications suggested that covarying items 4 and 5, 6 and 10, and 9 and 18 would create a significant improvement in model fit. These items had very high covariance (cov=772.611, cov=1117.546, cov=844.225 respectively), suggesting that examining at the wording of these items might dictate whether to eliminate redundant items despite possible model misspecification. During this phase, we deleted all items with pronoun errors that might have caused confusion for respondents, along with items 4 and 6 given their redundancy with items 5 and 10 respectively. We also deleted item 19 due to

overlapping constructs with 6.The subsequent CFA (35 items) appeared to improve model fit while eliminating the previous model misspecification, but was still poor (χ^2=987.365(554) p=.000, CFI= .754, TLI=.736, RMSEA 90% CI =.074-.091).

We then began a mass item-reduction based on item wording and R^2 values based on the previous 4-factor model. We reduced the scale to 15 items, with 4 items on social wanting, social learning, and social media interest each and 3 items on social liking. The explanations for why each item was dropped or retained can be found in Table 5, Appendix A. Once again, we see a poorly fitting, but much more reasonable model (χ^2(99)= 206.507, p=.000, CFI= .840, TLI=.807, RMSEA 90% CI = .078-.115), so we went back to create new sum scores and look at the distribution of scores for each subscale. While there was skew in the social wanting (skew=.564), social liking (skew=1.050), and social learning (=.937) sum scores, the skew and kurtosis in social media interest was so severe (skew=1.570, kurtosis=1.515), that there was little to no variability. 60.2% of the sample was below 45 out of 400 on the social media interest sum score. At this point, we decided to drop to social media factor from the model, with potential implications for future considerations.

Our final model had 11 items total with 4 items each for the social wanting and social learning factors, and 3 items for the social learning factor (χ^2(41)=75.265 p=.000, CFI=.919, TLI=.891, RMSEA 90% CI = .054-.115). Seeking to improve our model fit, we decided to covary items 14 and 27 as suggested by the modification indices and given the similarity of the items. This nested model seemed to improve our original model (χ^2(40)=63.371 p=.01, CFI = .944, TLI = .924, RMSEA 90% CI .035-.103), and using the Chi-Square difference test using the MLR scaling correction the modification provided a significant improvement in model fit (χ^2 (1.44)=9.51, p<.01). Thus, we reject the more parsimonious model in favor of the model with

covaried items. We also ran a conditional CFA with age, ID, ASD, PDD-NOS as exogenous covariates. The model fit was poor ($\chi^2(72)=137.491$ p=.00, CFI = .875, TLI = .818, RMSEA 90% CI .064-.108), but it is difficult to compare across models. None of the exogenous covariates explained a significant portion of variance in any of our factors (p>.05)

Despite this good model fit, the R^2 values are still relatively low for some items (R^2_{Mean} = .515). This is a low proportion of explained variance. More information about the model fit can be found in Appendix A, Tables 8-9. The path diagram is in Appendix A, Figure 1. Sum scores for the ASAS can be found in Table 10.

Relationship to the SRS

The SRS is coded so that a high score indicates high ASD symptoms while the ASAS is coded so that a low score indicates high ASD symptoms. Thus, a negative correlation between the two indicates a positive relationship in regards to ASD symptoms. Refer to Table 11 for the correlations between the SRS Total Score, SRS Social Motivation Subscale, ASAS Social Wanting, ASAS Social Learning, and ASAS Social Liking. These correlations demonstrate a moderate relationship between the SRS and the ASAS. However, the ASAS and SRS clearly are not entirely overlapping, establishing discriminant validity. Refer to Table 12 in Appendix A for the SRS Motivation items and their descriptive statistics.

Discussion

This is the first scale to date that has been developed to measure social reward processing in ASD. The items were developed and refined using expert feedback, and the slider scale supports a spectral approach to ASD symptomatology. We have established a 3-factor model of social reward processing, with social wanting, social liking, and social learning as the three independent factors with good model fit. The R^2 values for several items are below where we

would like them to be despite our good model fit. This low value is somewhat concerning in a small model, but the fit indices suggest that the model fits. This reduced-item scale will serve as a starting point for future development of the scale including many of the original items that we still believe may to be related to social reward processing deficits in ASD. The possible utility of this scale could be in an etiologically, to continue to establish evidence in favor of the SMT.

The greatest limitation of the present study is the small sample size. Our sample was too small to create enough variance to estimate the number of parameters we were originally trying to estimate. We settled on the number of current items because we did not reach the recommended five times the amount of items per sample size (Tabachnick & Fidell, 2014). Another limitation of the research is the heterogeneity of sample, in cognitive functioning, age, and diagnostic category. While conditional models including ID and age weren't significantly better than unconditional models, and no significant path was predicted from ID or age, it is still possible heterogeneity could be causing large amounts of unexplained variance in the data.

We feel confident that theory supporting our items served as the primary motivator to all of the changes we made throughout our fitting and refitting of models, without serious concerns about data mining. We concluded that after reaching our final model, any changes (e.g. changing items in and out) would be dishonest to our theory and mining for a good model fit. Some of the items with pronoun errors had high R^2 values, but we decided against including these due to the potential interpretive issues (e.g. rater/caregiver answering based on their own life).

Another potential limitation that arose while examining the distribution of the items was that there were two types of questions: affective (e.g., enjoy participating in group activities) and behavioral (e.g., does not want to come home from a birthday party or outing with friends). Most often, the behavioral items were the most bimodal distributions, given that a person can either

perform a behavior or not, while the affective state is likely more on a continuum. This could have caused a lot of noise in the data and it may have interfered with model fit.

When considering the potential clinical limitations, we do not have any confirmation of ASD diagnosis based on any of the standard instruments such as the ADOS or Autism Diagnostic Interview (ADI). Thus, it is difficult to make inferences for clinical implications, given that we do not have a confirmed diagnosis, nor do we have a profile of how ASD presents in an individual. We are relying on the sensitivity of our recruitment sources, as well as the AQ, in lieu of meeting these participants in person. I feel confident that our participants come from a reputable source and would likely meet criteria for ASD; however, at present, there are no replacements for a clinician's judgment. Another limitation is that we only have a caregiver report, while multiple sources for judgment (e.g., teacher) would aid in creating a more complete profile of social reward processing.

The relationship to the SRS is such that these two scales do not measure the same constructs, especially in relation to social motivation. However, the significant correlations indicate that there is a strong positive relationship (despite the negative correlations) between the ASAS and the SRS. This correlation is very important in that the SRS does assess ASD symptoms, as does the ASAS even though the two are measuring different constructs.

Future Directions

Despite the low sample size, the fourth factor of social media warrants farther investigation. It appeared that essentially none of our sample was using electronic communication, which may be due to age in that children may not use email or electronic communication. Unfortunately, there were not enough items in the scale that had variance in order to estimate the parameters. If we can expand the number of items asking about social

media, and can control for age, then we may be able to draw conclusions about how this social media interest relates to social reward processing in individuals with and without ASD.

While the ASAS is under development in becoming a clinically useful tool in ASD research, there is also a behavioral task that incorporates social reward processing. The Effort Expenditure for Reward Task (EEfRT) was developed to assess anhedonia in individuals with depression (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009). Based on a lever-pressing task used in non-human animal research, the EEfRT is a measure of how hard an individual will work for varying levels of reward (money). Recently, the EEfRT has been expanded into a version where participants play to win money for themselves and another participant in the study. The 'Vicarious EEfRT' is currently being used in a study of developmental aspects of reward processing, and is being administered alongside the ASAS. Using the 'Vicarious EEfRT' as part of the model, or as a predictor for ASAS score could prove useful for cross-validating these tasks.

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Appendix A

Table 1

Information on Participants

Demographics	n (N=114)	%
Sex		
Male	96	84.2
Female	18	15.8
Ethnicity		
White	87	76.3
African American	14	12.3
Asian	2	1.8
Hispanic	10	8.8
Other	1	.9
Intellectual Disability (ID)		
None	41	36.0
Mild	34	29.8
Moderate	26	22.8
Severe/Profound	8	7.0
Don't Know	5	4.2
Parent Reported Diagnosis		
ASD	84	73.7
HFA	24	21.3
Asperger's	23	20.2
Developmental Delay	14	12.3
PDD	1	.9

PDD-NOS	13	11.4
Source		
Online	107	93.9
In person	7	6.1

Table 2

Inter Item Correlation Coefficients for Social Wanting

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	-														
2	.245**	-													
3	.298**	.465**	-												
4	.071	.412**	.382**	-											
5	.165	.460**	.370**	.717**	-										
6	.279**	.335**	.428**	.396**	.462**	-									
7	.189*	.405**	.286**	.320**	.465**	.454**	-								
8	.374**	.617**	.526**	.414**	.537**	.457**	.532**	-							
9	.126	.351**	.311**	.222*	.327**	.238*	.392**	.331**	-						
10	.250**	.457**	.397**	.367**	.432*	.749**	.421**	.444**	.286**	-					
11	.261**	.400**	.465**	.303**	.434**	.527**	.594**	.590**	.356**	.472**	-				
12	.164	.341**	.248**	.107	.204*	.200*	.343**	.404**	.198*	.163	.404**	-			
13	.012	.302**	.320**	.368**	.498**	.362**	.488**	.302**	.334**	.277**	.472**	.255**	-		
14	.158	.452**	.295**	.350**	.548**	.442**	.402**	.670**	.459**	.421**	.551**	.296**	.383**	-	
15	.038	.404**	.284**	.401**	.349**	.229**	.193*	.314**	.323**	.200**	.195*	.400**	.298**	.341**	-

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.05 level (2-tailed).

Table 3

Inter It

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Table 4

Inter Item Correlation Coefficients for Social Learning

Item	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
30	-															
31	.041	-														
32	-.071	.232*	-													
33	-.088	.241**	.438**	-												
34	-.020	.248**	.399**	.567**	-											
35	.082	.354**	.385**	.483**	.338**	-										
36	-.013	.236*	.431**	.558**	.473**	.470**	-									
37	-.051	.161	.416**	.429**	.363**	.336**	.361**	-								
38	-.012	.221*	.392**	.561**	.408**	.410**	.613**	.303**	-							
39	-.017	.192*	.418**	.553**	.189*	.419**	.511**	.371**	.558**	-						
40	.002	.078	.351**	.397**	.497**	.286**	.304**	.249**	.300**	.284**	-					
41	-.008	.102	.555**	.542**	.497**	.428**	.537**	.389**	.437**	.397**	.427**	-				
42	.102	.127	.493**	.585**	.566**	.557**	.446**	.305**	.469**	.397**	.535**	.592**	-			
43	-.112	.065	.375**	.365**	.271**	.294**	.206*	.342**	.325**	.364**	.299**	.309**	.297**	-		
44	.008	.179	.333**	.412**	.299**	.367**	.357**	.407**	.274**	.340**	.301**	.319**	.410**	.485**	-	
45	-.140	.100	.437**	.480**	.471**	.220*	.343**	.277**	.413**	.408**	.422**	.570**	.470**	.587**	.422**	-

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.05 level (2-tailed).

Table 5

Autism Social Anhedonia Scale Questions and Justifications for Dropping Items

Item Wording	Original Subscale	Dropped/Retained	Justification
1. Decline invitations to social activities	Social Wanting	Dropped	Reverse worded
2. Want friends	Social Wanting	**Retained**	High R^2, no overlapping constructs with other retained items
3. Miss friends of extended family between visits	Social Wanting	Dropped	Low R^2
4. Join clubs or groups to meet new people	Social Wanting	Dropped	Redundant with 5
5. Actively seek out social interactions (e.g., extracurricular social activities)	Social Wanting	**Retained**	High R^2, no overlapping constructs with other retained items
6. Enjoy sending holiday or birthday cards	Social Wanting	Dropped	Cards may be outdated, gifts more inclusive
7. Ask for help making friends	Social Wanting	Dropped	Low R^2
8. Ask for opportunities to see friends	Social Wanting	**Retained**	High R^2, no overlapping constructs with other retained items
9. Check texts or email for messages from friends	Social Wanting	Dropped	Low R^2
10. Enjoy giving gifts to others	Social Wanting	Dropped	Low R^2
11. Go out of your way to help a friend in need	Social Wanting	Dropped	Grammar/Pronouns

12. Worry about what other people think about you	Social Wanting	Dropped	Grammar/Pronouns
13. Ask about how to develop social relationships	Social Wanting	Dropped	Potential confound with verbal language skills, perhaps not solely social wanting
14. Try to involve friends in interests	Social Wanting	**Retained**	High R^2, no overlapping constructs with other retained items
15. Want to be popular	Social Wanting	Dropped	Low R^2
16. Enjoy solitary activities	Social Liking	Dropped	Reverse worded
17. Enjoy being with other people	Social Liking	**Retained**	High R^2, no overlapping constructs with other retained items
18. Enjoy online communication with other people (e.g., texting, email)	Social Liking	Dropped	Age inappropriate, creating separate factor
19. Enjoy receiving holiday or birthday cards	Social Liking	Dropped	Cards may be outdated, gifts more inclusive
20. Enjoy spending free time on social media interacting with others (facebook, instagram, twitter, etc.)	Social Liking	Dropped	Age inappropriate, creating separate factor
21. Like hearing and discussing	Social Liking	Dropped	Age inappropriate, creating separate factor

celebrity news			
22. Like to gossip	Social Liking	Dropped	Loaded onto 4th factor, later dropped
23. Not want to come home from a birthday party or an outing with friends	Social Liking	Dropped	Low R^2
24. Have a preferred group of classmates or peers with whom you associate	Social Liking	Dropped	Grammar/Pronouns
25. Smile when around other people	Social Liking	Dropped	Low R^2
26. Seem to be energized by time with friends and extended family	Social Liking	Dropped	Low R^2
27. Enjoy participating in group activities (e.g., team sports, clubs)	Social Liking	**Retained**	High R^2, no overlapping constructs with other retained items
28. Put up pictures of friends in his/her room	Social Liking	**Retained**	High R^2, no overlapping constructs with other retained items
29. Feel that your favorite time of the day is when socializing with others	Social Liking	Dropped	Grammar/Pronouns
30. Repeat social mistakes	Social Learning	Dropped	Reverse worded
31. Avoid peers who have been mean	Social Learning	Dropped	Low R^2
32. Incorporate others' likes and dislikes	Social Learning	Dropped	Too many social learning

in conversations			items compared to rest of model with moderate R^2
33. Try to change inappropriate behavior based on peer feedback	Social Learning	**Retained**	High R^2, no overlapping constructs with other retained items
34. Try to change inappropriate behavior based on parent feedback	Social Learning	Dropped	Low R^2
35. Learn quickly who is friendly in new situations	Social Learning	Dropped	Low R^2
36. React in a way that diffuses the situation when teased	Social Learning	**Retained**	High R^2, no overlapping constructs with other retained items
37. Interact differently with different peers	Social Learning	Dropped	Low R^2
38. Talk about social problem solving (for example, resolving disagreements with friends)	Social Learning	Dropped	Low R^2
39. Identify with a social niche	Social Learning	Dropped	Low R^2
40. Do better in social situations now than in the past	Social Learning	Dropped	Low R^2
41. Understand others' perspectives	Social Learning	**Retained**	High R^2, no overlapping constructs with other retained items
42. Transfer new social skills from one situation to	Social Learning	**Retained**	High R^2, no overlapping constructs with other retained items

another			
43. Use social sayings (slang) from TV/movies with peers	Social Learning	Dropped	Low R^2
44. Imitate others' social behavior	Social Learning	Dropped	Low R^2
45. Use humor in social interactions	Social Learning	Dropped	Low R^2

R^2 Value is from 4 factor CFA with 42 items (Table 6)

Table 6

R-Square Values from 4 Factor CFA

Item	Estimate	S.E.	Two Tail Est./S.E.	P-Value
ASAS_2	0.444	0.091	4.871	0.000
ASAS_3	0.336	0.083	4.063	0.000
ASAS_5	0.533	0.087	6.141	0.000
ASAS_7	0.366	0.075	4.873	0.000
ASAS_8	0.632	0.078	8.058	0.000
ASAS_9	0.587	0.132	4.462	0.000
ASAS_10	0.390	0.077	5.032	0.000
ASAS_13	0.305	0.103	2.956	0.003
ASAS_14	0.540	0.086	6.300	0.000
ASAS_15	0.204	0.078	2.268	0.009
ASAS_17	0.481	0.108	4.460	0.000
ASAS_18	0.669	0.115	5.840	0.000
ASAS_20	0.648	0.116	5.593	0.000
ASAS_21	0.440	0.175	2.511	0.000
ASAS_22	0.353	0.175	2.013	0.044
ASAS_23	0.486	0.085	5.731	0.000
ASAS_25	0.294	0.079	3.723	0.000
ASAS_26	0.392	0.094	4.156	0.000
ASAS_27	0.505	0.078	6.471	0.000
ASAS_28	0.351	0.103	3.402	0.001
ASAS_31	0.076	0.054	1.403	0.161
ASAS_32	0.437	0.097	4.490	0.000
ASAS_33	0.600	0.064	9.434	0.000
ASAS_34	0.428	0.083	5.158	0.000
ASAS_35	0.389	0.118	3.294	0.001
ASAS_36	0.463	0.095	4.882	0.000
ASAS_37	0.276	0.087	3.163	0.002
ASAS_38	0.454	0.087	5.234	0.000
ASAS_39	0.381	0.089	4.308	0.000
ASAS_40	0.312	0.083	3.760	0.000
ASAS_41	0.541	0.077	7.041	0.000
ASAS_42	0.563	0.071	7.980	0.000
ASAS_43	0.280	0.083	3.353	0.001
ASAS_44	0.304	0.085	3.583	0.000
ASAS_45	0.402	0.083	4.854	0.000

Table 7
Geomin Rotated Loadings for 4-Factor EFA

Item	1	2	3	4
ASAS_2	0.663*	0.117	-0.07	-0.051
ASAS_3	0.501*	0.286	-0.09	-0.057
ASAS_4	0.148	0.637*	-0.03	0.024
ASAS_5	0.286	0.557	0.047	-0.005
ASAS_6	0.331	0.345	0.158	0.003
ASAS_7	0.517*	0.123	-0.004	0.103
ASAS_8	0.767*	0.149	0.036	-0.203*
ASAS_9	0.549*	-0.049	-0.100	0.565*
ASAS_10	0.416*	0.212	0.198	0.006
ASAS_11	0.582*	0.018	0.256*	0.034
ASAS_12	0.611*	-0.283	0.089	0.001
ASAS_13	0.201	0.202	0.262	0.231
ASAS_14	0.557*	0.101	0.229*	0.011
ASAS_15	0.314	0.144	0.061	0.127
ASAS_17	0.373	0.505*	-0.122	-0.066
ASAS_18	0.571	-0.287*	0.021	0.658*
ASAS_19	0.621*	0.058	0.034	0.112
ASAS_20	0.356	-0.006	-0.002	0.672*
ASAS_21	0.006	0.171	0.275	0.605*
ASAS_22	0.004	0.336	0.25	0.466*
ASAS_23	0.671*	0.167	-0.012	0.018
ASAS_24	0.261	-0.161	0.590*	-0.214
ASAS_25	0.014	0.506*	0.114	-0.112
ASAS_26	0.088	0.494*	0.208	-0.235*
ASAS_27	0.186	0.571	0.101	0.011
ASAS_28	0.003	0.602*	0.136	0.304*
ASAS_29	0.300	0.608*	-0.005	0.098
ASAS_31	0.079	-0.209	0.435*	-0.229
ASAS_32	0.200	0.081	0.508*	0.044
ASAS_33	-0.039	0.106	0.758*	-0.006
ASAS_34	0.064	-0.02	0.683*	-0.142
ASAS_35	-0.047	0.349*	0.508*	-0.062
ASAS_36	-0.093	0.012	0.701*	0.168
ASAS_37	0.061	-0.102	0.584*	-0.055
ASAS_38	0.019	0.102	0.583*	0.192
ASAS_39	-0.057	-0.026	0.618*	0.201
ASAS_40	0.051	0.066	0.514*	-0.028
ASAS_41	-0.020	0.167	0.635*	0.078
ASAS_42	-0.030	0.188	0.645*	0.09
ASAS_43	0.400*	-0.055	0.349*	-0.006
ASAS_44	0.063	0.159	0.451*	-0.017
ASAS_45	0.226	-0.047	0.512*	0.092

* Significant at 5% level

Table 8

R^2 Values for Final CFA

Item	Estimate	S.E.	Two-Tail Est./S.E.	P-Value
ASAS_2	0.395	0.098	4.038	0.000
ASAS_5	0.554	0.097	5.689	0.000
ASAS_8	0.635	0.090	7.064	0.000
ASAS_14	0.624	0.088	1.083	0.000
ASAS_17	0.343	0.098	3.492	0.000
ASAS_27	0.573	0.079	7.281	0.000
ASAS_28	0.354	0.104	3.423	0.001
ASAS_33	0.577	0.088	6.538	0.000
ASAS_36	0.432	0.112	3.849	0.000
ASAS_41	0.603	0.103	5.874	0.000
ASAS_42	0.571	0.096	5.925	0.000

Table 9

Standardized Factor Loadings for Final CFA

Item	Estimate	S.E.	Est./S.E.	P-value
WANT				
ASAS_2	0.629	0.078	8.076	0.000
ASAS_5	0.745	0.065	11.378	0.000
ASAS_8	0.797	0.056	14.127	0.000
ASAS_14	0.790	0.056	14.166	0.000
LIKE				
ASAS_17	0.686	0.084	6.985	0.000
ASAS_27	0.595	0.087	6.846	0.000
ASAS_28	0.757	0.052	14.563	0.000
LEARN				
ASAS_33	0.760	0.058	13.076	0.000
ASAS_36	0.657	0.085	7.697	0.000
ASAS_41	0.776	0.066	11.749	0.000
ASAS_42	0.756	0.064	11.851	0.000
ASAS_27 with ASAS_14	-0.491	0.150	-3.265	0.001

Table 10

Descriptive Statistics for Sum Scores of 3 Subscales

Subscale	Mean	SD	Median	Skewness	Kurtosis	Range	Reported Range
Social Wanting	115.5	116.2	130.0	.564	-.691	0-400	0-400
Social Liking	101.7	73.3	88.0	1.050	.704	0-300	0-300
Social Learning	101.3	84.1	67.0	.937	.081	0-400	0-340

Table 11

Interscale Correlations for SRS and ASAS

	SRS Motivation	SRS Total	Social Wanting	Social Liking	Social Learning
SRS Motivation Subscale	-				
SRS Total Score	.688**	-			
ASAS Social Wanting	-.478**	-.346**	-		
ASAS Social Liking	-.468**	-.371**	.640**	-	
ASAS Social Learning	-.331**	-.475**	.422**	.469**	-

**. Pearson correlation is significant at the 0.01 level (2-tailed).

Table 12

SRS Motivation Subscale Descriptive Statistics

	Mean	SD	Median	Skewness	Kurtosis
Seems much more fidgety in social situations than when alone	1.90	0.86	2.00	-0.18	-0.91
Seems self-confident when interacting with others	1.91	0.90	2.00	-0.64	-0.21
Would rather be alone than with others	1.55	0.99	1.00	0.16	-1.06
Clings to adults, seems too dependent on them	1.21	1.05	1.00	0.22	-1.24
Has good self-confidence	1.64	0.83	2.00	-0.25	-0.22
Does not join group activities unless told to do so	1.69	1.00	2.00	-0.03	-1.16
Avoids starting social interactions with peers or adults	1.42	0.98	1.00	0.20	-0.93
Avoids people who want to be emotionally close to him or her	0.85	0.85	1.00	0.77	-0.05
Separates easily from caregivers	1.12	1.02	1.00	0.59	-0.72
Is too tense in social settings	1.20	0.92	1.00	0.41	-0.61
Stares or gazes off into space	1.16	0.81	1.00	0.25	-0.45

Figure 1

Path Diagram for Final CFA

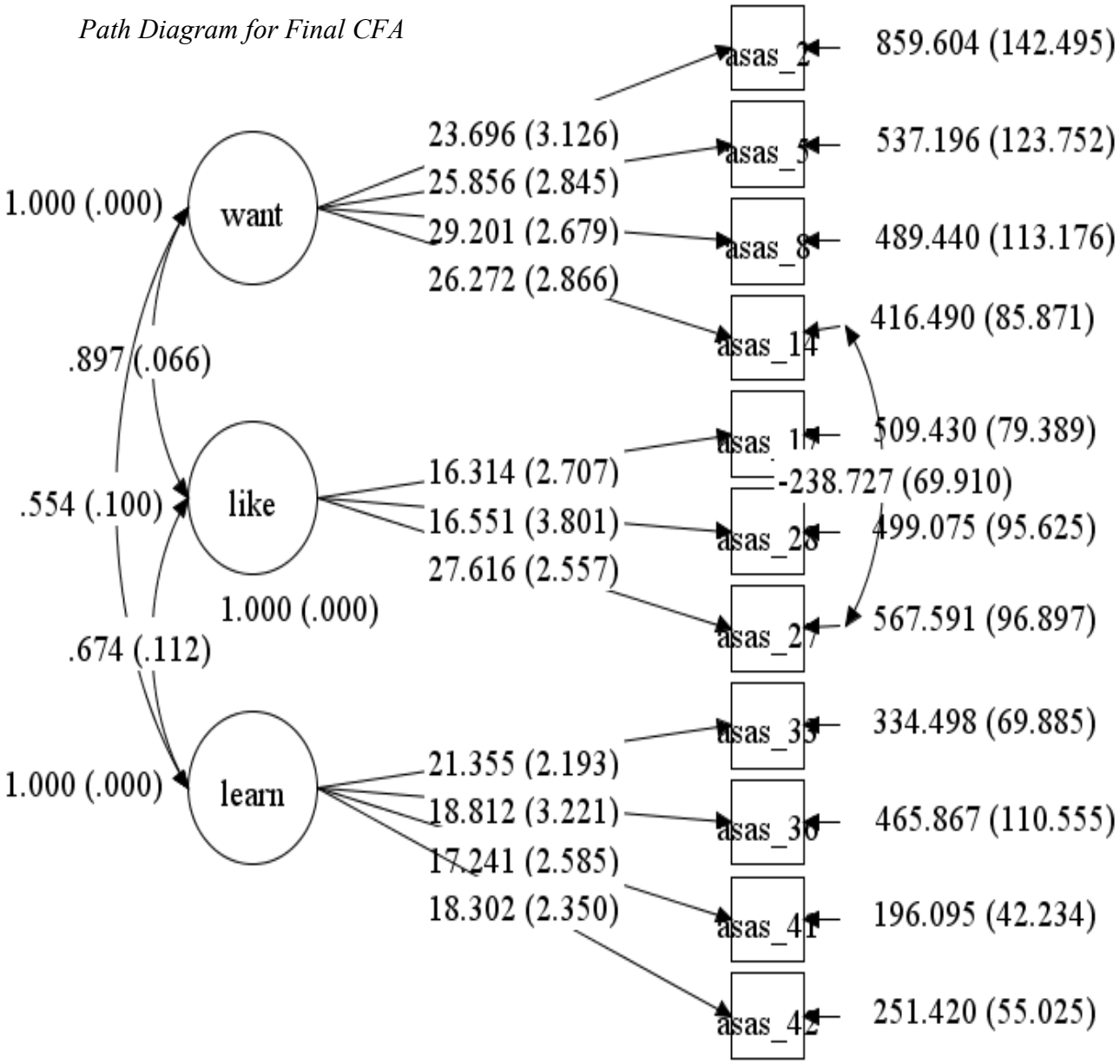

Figure 2

Qualtrics Interface for ASAS